```
#-------------------------------------------------------------------------------
        .data   0x10000000          # data section starts in
                                    # address 0x10000000
aa:     .word   0x0005              # aa is in the 1st data address
bb:     .word   0x000a              # bb is in the following address
cc:     .word   ?                   # cc is in the 3rd address
#-------------------------------------------------------------------------------
        .globl  main
        .text   0x0400000
#-------------------------------------------------------------------------------
main:
        lw      $t1,aa              # $t1 = aa
        lw      $t2,bb              # $t2 = bb
        slt     $t3,$t1,$t2         # if aa<bb $t3=1, else $t3=0
        beq     $t3,$zero,agtb      # if $t3=1 goto agtb
        sw      $t2,cc              # else write bb into cc
        j       end
agtb:   sw      $t1,cc              # write aa into cc
end:    j       end
#-------------------------------------------------------------------------------
```

The assembler translates the ***lw $t1,aa*** instruction to two consecutive instructions:

```
        lui     $at,0x1000
        lw      $t1,0($at)
```

Preprocessing

- Macro:

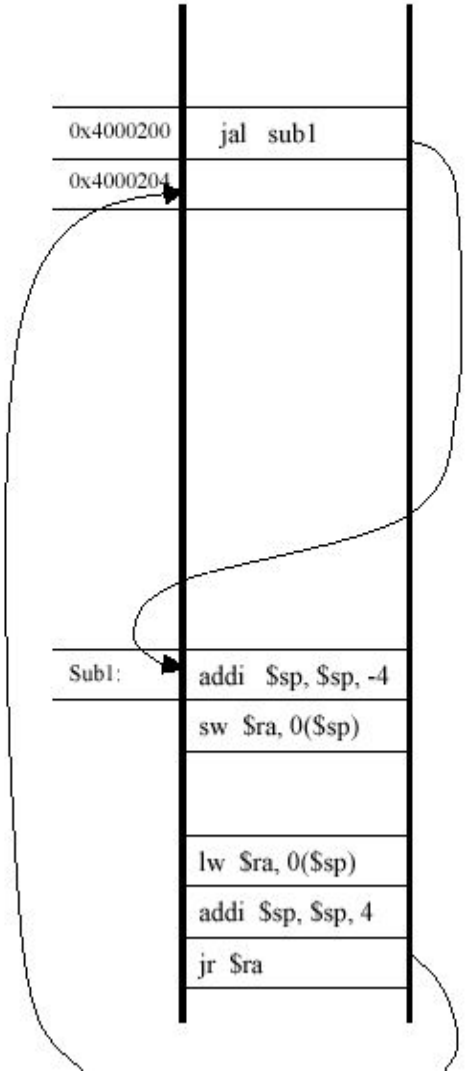
```
.macro      mul3($arg)
add     $t0, $zero, $arg      # save $arg in $t0
add     $arg, $arg, $arg      # double $arg
add     $arg, $t0, $arg       # add $t0
.end_macro
```

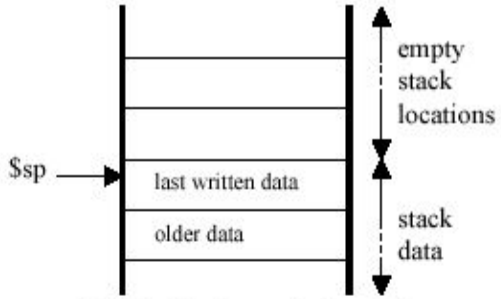
- Code:

```
lui     $at, 0x1000
lw      $s5, 40($at)
mul3($s5)
sw      $s5, 40($at)
```

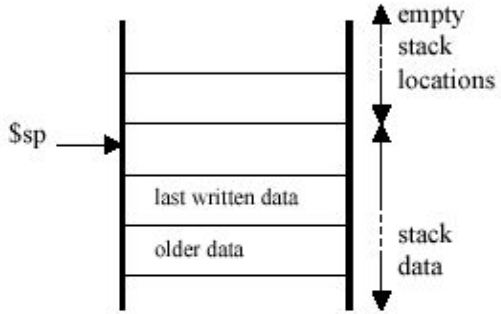
- After preprocessing

```
lui     $at, 0x1000
lw      $s5, 40($at)
add     $t0, $zero, $s5       # save $arg in $t0
add     $s5, $s5, $s5         # double $arg
add     $s5, $t0, $s5         # add $t0
sw      $s5, 40($at)
```

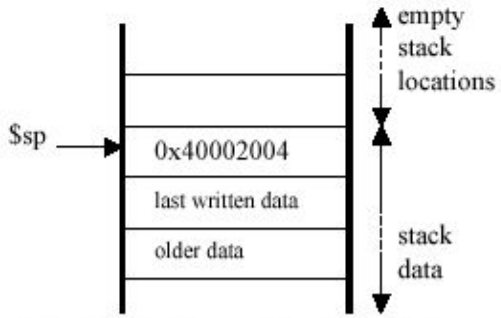




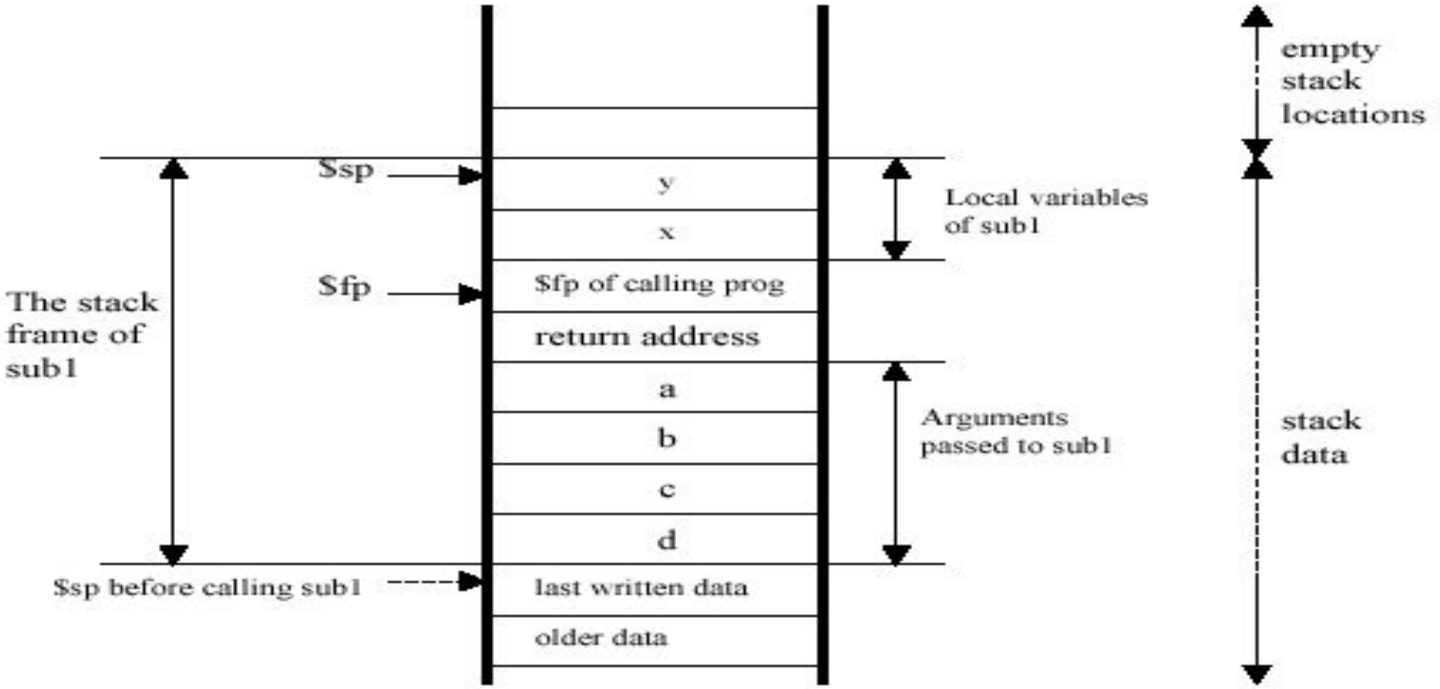
(a)-The Stack map before jal



(b) - The Stack map after the addi instruction



(c) - The Stack map after the addi + sw, i.e., during the routine



The routine sub1 has the form of:

```
sub1( int p0, int p1, int p2, int p3, int a, int b, int c,  int d)
{
   int x,y;

   ---------
   ---------
   ---------
}
```

The first 4 arguments p0-p3 are transferred through registers $a0-$a1

Figure 5.5 - The Stack frame memory map

:Calling procedure

```
addi   $sp, $sp, -16      # prepare room for 4 words in stack
lw     $t1,d              # read d from memory
sw     $t1, 12($sp)       # push d into the stack
lw     $t1,c
sw     $t1, 8($sp)        # push c into the stack
lw     $t1,b
sw     $t1, 4($sp)        # push b into the stack
lw     $t1,a
sw     $t1, 0($sp)        # push a into the stack
jal    sub1               # call sub1
addi   $sp, $sp, 16       # release (pop) the 4 words
```

:Callee procedure

```
:Sub1 :  addi    $sp, $sp, -8       #  allocate 2 words for the $fp and $ra
         sw      $ra, 4($sp)        #  save the $ra
         sw      $fp, 0($sp)        #  save the $fp
         add     $fp, $sp, $zero    #  set the new value for the $fp
         addi    $sp, $sp, -8       #  allocate 2 words for the local variables x and y
         ------------------------
         ------------------------
         ------------------------
         ------------------------
         # here we write the body of  the routine:

         #  In the routine we access x and y by :
         sw      $s3, -4($fp)       # store $s3 in x
         lw      $t5, -8($fp)       # load $t5 with y

         # We access the arguments a,b,c,d by:
         lw      $t1, 8($fp)        # read a from the stack into $t1
         lw      $t2, 12($fp)       # read b from the stack into $t2
         lw      $t3, 16($fp)       # read c from the stack into $t3
         lw      $t4, 20($fp)       # read d from the stack into $t4

         # at the same time, we can use the $sp to spill registers to the stack
         # and still use the $fp to access arguments and local variables
         ------------------------
         ------------------------
         ------------------------
         ------------------------
         # We end the routine by:
         add     $sp, $fp, $zero    # release the  local variables
         lw      $ra, 4($sp)        # retrieve $ra
         lw      $fp, 0($sp)        # retrieve $fp
         addi    $sp, $sp, 8        # release 2 more words
         jr      $ra                # return to the calling program
```

Single Cycle